CLAIMS

1. A method for fabricating thin film oxides, the method comprising:

forming a substrate;

treating the substrate at temperatures equal to and less than 360° C, using a high density (HD) plasma source; and,

forming an M oxide layer overlying the substrate where M is an element selected from a group including elements chemically defined as a solid and having an oxidation state in a range of +2 to +5.

2. The method of claim 1 wherein treating the substrate at temperatures equal to and less than 360° C, using an HD plasma source includes using an inductively coupled plasma (ICP) source.

3. The method of claim 2 wherein forming a substrate includes forming a substrate including M; and,

wherein using an ICP source includes plasma oxidizing the substrate.

4. The method of claim 3 wherein plasma oxidizing the substrate includes inductively coupling plasma:

at a temperature of 360° C;

in a range of 13.56 to 300 megahertz (MHz) with a power density up to 10 watts per square centimeter (W/cm^2);

at a pressure of up to 500 milliTorr (mTorr);

with a mixture of inert gas and oxygen in a ratio of approximately 10:1 to 200:1; and,

with a total gas flow of approximately 50 to 200 standard cubic centimeters per minute (sccm).

5. The method of claim 4 wherein inductively coupling plasma includes varying a substrate bias in a range of 50 kilohertz (KHz) to 13.56 MHz with a power density up to 3 W/cm^2.

6. The method of claim 4 wherein inductively coupling plasma with a mixture of inert gas and oxygen includes mixing oxygen with inert gas selected from the group including helium, argon, and krypton.

7. The method of claim 4 wherein forming a substrate including M includes forming a silicon layer.

8. The method of claim 7 further comprising:

forming a transparent substrate layer; and,

forming a diffusion barrier overlying the transparent substrate layer and underlying the silicon layer;

wherein forming a silicon layer includes forming transistor channel, source, and drain regions in the silicon layer;

wherein forming an M oxide layer includes forming a gate dielectric layer of the oxide; and,

the method further comprising:

forming a gate electrode overlying the gate dielectric layer.

9. The method of claim 8 wherein forming a gate dielectric layer of the oxide includes forming a dielectric layer with:

a fixed oxide charge density of less than 5 x 10^{11} per square centimeter ($/cm^2$);

an interface trap concentration of approximately .9 x 10^{10} to 8 x 10^{10} per square centimeter – electron volt ($/cm^2$ eV);

a flat band voltage shift of less than 1 V;

a leakage current density lower than 10^{-7} amperes per square centimeter (A/cm^2) at an applied electric field of 8 megavolts per centimeter (MV/cm); and,

a breakdown field strength greater than 10 MV/cm.

10, The method of claim 7 wherein forming an M oxide layer includes forming a silicon oxide layer with a refractive index between approximately 1.45 and 1.47.

11. The method of claim 3 wherein forming a substrate including M includes:

forming a base layer of a material; and,

depositing a thin film of element M overlying the base layer; and,

wherein plasma oxidizing the substrate includes plasma oxidizing the thin film of M.

12. The method of claim 2 wherein using an ICP source includes using an HD plasma enhanced chemical vapor deposition (HD-PECVD) process to treat the substrate; and,

wherein forming an M oxide layer overlying the substrate includes depositing the M oxide layer.

13. The method of claim 12 wherein using an HD-PECVD process to treat the substrate includes inductively coupling plasma:

in a range of 13.56 to 300 MHz with a power density up to 10 W/cm^2;

at a pressure of up to 500 mTorr; and,

with a mixture of reactive gases and precursor compounds having M in a decomposable form, the gases and precursor compounds in a ratio selected in accordance with the valence state of M.

14. The method of claim 13 wherein inductively coupling plasma includes varying a substrate bias in a range of 50 KHz to 13.56 MHz with a power density up to 3 W/cm^2.

15. The method of claim 13 wherein forming a substrate includes forming a silicon layer.

16. The method of claim 15 wherein inductively coupling plasma with a mixture of reactive gases and precursor compounds having M in a decomposable form, the gases and precursor compounds in a ratio selected in accordance with the valence state of M includes inductively coupling plasma with a mixture of SiH_4, N_2O, and N_2 gases in a ratio of approximately 10:100:50 to 25:100:50.

17. The method of claim 16 further comprising:

forming a transparent substrate layer; and,

forming a diffusion barrier overlying the transparent substrate layer and underlying the silicon layer;

wherein forming a silicon layer includes forming transistor channel, source, and drain regions in the silicon layer;

wherein depositing the M oxide layer includes depositing a gate dielectric layer; and,

the method further comprising:

forming a gate electrode overlying the gate dielectric layer.

18. The method of claim 17 wherein forming a gate dielectric layer includes forming a dielectric layer with:

a fixed oxide charge density of less than $5 \times 10^{11}/cm^2$;

an interface trap concentration of approximately 2×10^{10} to $8 \times 10^{10}/cm^2\ eV$;

a flat band voltage shift of less than 1 V;

a leakage current density lower than $10^{-7}\ A/cm^2$ at an applied electric field of 8 MV/cm; and,

a breakdown field strength greater than 10 MV/cm.

19, The method of claim 15 wherein depositing the M oxide layer includes depositing a silicon oxide layer with a refractive index between approximately 1.45 and 1.47.

20. The method of claim 1 wherein forming a substrate includes forming a substrate where M is silicon selected from the group

including amorphous silicon, microcrystalline silicon, and polycrystalline silicon.

21. The method of claim 1 wherein forming, overlying the substrate, an M oxide layer includes forming an M oxide selected from the group including M binary oxides and M multi-component oxides.

22. The method of claim 1 wherein treating the substrate at temperatures equal to and less than 360° C using an HD plasma source includes using a plasma source selected from the group including electron cyclotron resonance (ECR) plasma sources and cathode-coupled plasma sources.

23. A method for fabricating thin film oxides, the method comprising:

forming a substrate;

treating the substrate at temperatures equal to and less than 360° C, using a transmission/transformer coupled plasma source; and,

forming, overlying the substrate, an M oxide layer where M is selected from a group including elements chemically defined as a solid and having an oxidation state in a range of +2 to +5.

24. An in-situ method for fabricating thin film oxides, the method comprising:

in a film processing chamber, forming a substrate;

leaving the substrate in the film processing chamber, treating the substrate at temperatures equal to and less than 360° C, using a high density (HD) plasma source; and,

in the film processing chamber, forming, overlying the substrate, an M oxide layer where M is selected from a group including elements chemically defined as a solid and having an oxidation state in a range of +2 to +5.